Accident Sequence Precursor (ASP) Program Description and Comparison with Significance Determination Process (SDP) and Event Assessment Processes

1.0 Introduction

The Accident Sequence Precursor (ASP) Program involves the systematic review and evaluation of operating events that have occurred at licensed U.S. commercial nuclear power plants. The ASP Program identifies and categorizes precursors to potential severe core damage accident sequences.

2.0 Background

The U.S. Nuclear Regulatory Commission (NRC) established the ASP Program in 1979 in response to the Risk Assessment Review Group report (see NUREG/CR-0400, September 1978). Evaluations done for the 1969–1979 period were the first efforts in this type of analysis.

3.0 Program Objectives

The primary objective of the ASP Program is to systematically evaluate U.S. nuclear plant operating experience to identify, document, and rank operating events most likely to lead to inadequate core cooling and core damage (precursors).

In addition, the other objectives of the ASP Program are to —

- Provide a measure for trending nuclear power plant core damage risk.
- Provide a partial check on dominant core damage scenarios predicted by probabilistic risk assessments (PRAs).
- Provide feedback to regulatory activities.
- Evaluate the adequacy of NRC programs.

The ASP Program provides the basis for two of five performance measures for the performance goal to maintain safety in the reactor safety arena of the NRC's Strategic Plan:

- "Zero events per year identified as a *significant* precursor of a nuclear accident." The Strategic Plan defines a *significant* precursor as an event that has a 1 in 1000 (10^{-3}) or greater probability of leading to a reactor accident.

- "No more than one significant adverse trend in industry safety performance, with no trend exceeding Abnormal Occurrence Criterion I.D.4." One of the indicators that the NRC's Industry Trends Program uses to assess industry performance against this measure is the trend of all precursors identified by the ASP Program.

4.0 Precursor Definitions and Threshold

Definition of an operating event. An operating event can be:

- An actual initiating event (e.g., loss of offsite power, loss-of-coolant accident), or

- A condition found during a test, inspection, or engineering evaluation involving a reduction in safety system reliability or function for a specific duration.

The ASP Program uses the term operating event interchangeably with the terms "initiating event" or "condition."

Definition of a precursor. An accident sequence precursor is an operating event that is an important element of a postulated core-damage accident sequence.

Accident sequences of interest to the ASP Program are those that would have resulted in inadequate core cooling and severe core damage if additional failures had occurred.

Precursors are initiating events or conditions that, when coupled with one or more postulated events, could result in a plant condition involving inadequate core cooling. The ASP Program uses nominal initiating event frequencies and/or nominal failure probabilities for estimating the conditional probability of the postulated event portion of the analysis.

The ASP Program currently performs detailed analyses of operating events affecting at-power and shutdown conditions.

At-power precursor. An at-power precursor is an operating event that usually meets ***one*** of the following criteria:

- The total failure of a system required to mitigate the effects of a core damage initiator.
- The degradation of two or more safety system trains required to mitigate effects of a core damage initiator.
- The degradation of one safety system train for an extended period of time.
- A core damage initiator such as a loss of offsite power or small-break loss-of-coolant accident.
- A reactor trip or loss-of-feedwater with a degraded safety system.

Shutdown Precursor. A shutdown precursor is an operating event that meets both of the following criteria:

- A core damage initiator such as a loss of shutdown cooling, loss of reactor vessel inventory, loss of offsite power, unavailability of emergency power, or a loss-of-coolant accident, and
- The initiator could only have occurred with the plant in a shutdown condition.

CCDP vs. Importance. The figure of merit for ASP analyses is the conditional core damage probability (CCDP) for initiating events and the increase in core damage probability (ΔCDP) or *importance* for conditions.[1] The *importance* is the measure of the incremental increase between the CCDP for the period in which the condition existed and the nominal CDP for the same period.

Threshold. An initiating event with a CCDP or a condition with an *importance* greater than or equal to 1×10^{-6} is classified as a precursor in the ASP Program.

[1] The CCDP and importance are equal for precursors involving initiating events.

5.0 Comparison of ASP Program with SDP and Event Assessment Processes[2]

Accident Sequence Precursor Program. The main purpose of the ASP Program is to review and evaluate operational experience to identify precursors to potential severe core damage sequences. The ASP Program provides a comprehensive risk analysis of initiating events (e.g., reactor trip initiator) and degraded conditions (e.g., equipment or functional degradations) at nuclear power plants.

Significance Determination Process. The main purpose of the SDP is to determine the safety significance of inspection findings. The SDP is part of the Reactor Oversight Process and evaluates inspection findings in all seven cornerstones of safe operation — initiating events, mitigating systems, barrier integrity, emergency preparedness, public radiation safety, worker radiation safety, physical protection. The SDP uses a three-phase approach to determine the significance of inspection findings in the initiating events, mitigating systems, and barrier integrity cornerstones.

NRC Incident Investigation Program (i.e., Event Response Evaluation). The main purpose of the event response evaluation element of the NRC Incident Investigation Program is to determine the appropriate level of reactive inspection in response to a significant event. The event response evaluation process is part of the Reactor Oversight Process and provides a prompt evaluation of significant operational events (as defined in Management Directive 8.3, "NRC Incident Investigation Program") involving reactor and fuel cycle facilities and NRC or Agreement State licensed materials.

5.1 Summary of Similarities and Differences

The discussion below compares the various programs and is focused on the part of the programs used to evaluate actual events and degraded conditions at nuclear power plants. These events and conditions correspond to three of the seven cornerstones of safe operation —

[2] This section summarizes the differences and scopes of the three programs as documented in a memorandum to the Commission, entitled "Response to Staff Requirements Memorandum SRM-M020319, Dated April 1, 2002, Briefing on Office of Nuclear Regulatory Research (RES) Programs, Performance, and Plans," dated July 12, 2002 (ADAMS Accession no. ML0217600040).

initiating events, mitigating systems, and barrier integrity.

Similarities Between ASP, SDP, and Event Response Processes. The risk models and technical methods used in ASP, SDP Phase 3, and event response assessments are generally similar. The Standardized Plant Analysis Risk (SPAR) models are typically used in all three processes, although the licensee's probabilistic risk assessment (PRA) can be used in SDP and event response assessments. Most of the methods applied in SDP Phase 3 and event response assessments are derived from the ASP Program; however, other methods, such as use of the licensee's generated PRA results and simplified hand calculations, are permitted by the procedures. The SDP Phase 1 is a screening procedure that identifies the inspection findings to be evaluated under SDP Phase 2 or 3. The ASP and event response processes also employ screening procedures. Risk significance estimation under the SDP Phase 2 process is quite different from ASP, SDP Phase 3, and event response processes. The SDP Phase 2 process uses site-specific, risk-informed inspection notebooks to assess the risk significance (i.e., color) of inspection findings. The ASP, SDP Phase 3, and event response evaluation processes primarily use SPAR models in the analysis of events and degraded conditions.

Differences Between ASP, SDP Phase 3, and Event Response Processes. Some differences are inherent in the intended function of the system. For example, the timeliness in which results are needed has a significant impact on the level of detail that goes into an analysis and the amount of event-related information available at the time the results are needed by decision makers. More available time can reduce the uncertainties in the results. Another example is the scope of the events analyzed. Not all systems evaluate all events and degraded conditions. Some differences are highlighted below.

- *Applicability.* Inspection findings with a greater-than-green risk significance are most likely precursors in the ASP Program. However, not all precursors result in an inspection finding. These precursors include initiating events (actual reactor trips) or degraded conditions where no deficiency in the licensee's performance was identified. For example, an extended loss of offsite power event caused by an act of nature will be a precursor, most likely in the 10^{-4} conditional core damage probability (CCDP) range.

  The SDP would screen out this event if no performance deficiency was found. Significant events and degraded conditions that result in a reactive inspection (i.e., special inspection, augmented inspection, incident investigation) based on an event response evaluation would be analyzed in the ASP Program. In the loss of offsite power example above, an augmented inspection or incident investigation would be considered based on a CCDP in the 10^{-4} range.

  Concurrent multiple degraded conditions are analyzed together in the ASP Program. In the SDP program, concurrent multiple degraded conditions that involve different performance deficiencies are analyzed individually.

- *Analyses.* Event response assessment is expected to be performed within a day or two after the event notification. Lack of detailed information regarding the event or degraded conditions at the time of the assessment sometimes requires use of engineering judgment or simplistic assumptions. In such a case, the point estimate of the risk assessment carries a large uncertainty. However, for determining what reactive inspection may be most appropriate, based on a risk-informed as opposed to risk-based process, the emphasis is not on the specific value but on the range of the safety significance.